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PROCEEDINGS OF THE MANITOBA SEDIMENT ISSUES WORKSHOP: NOVEMBER 18-19, 1986 WINNIPEG, MANITOBA

T.R. YUZYK

WATER RESOURCES BRANCH
INLAND WATERS DIRECTORATE
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Canada

Western and Northern Region

IWD-WNR(M)-WRB-SS-87-1

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6700-4 (0737H)

Participants,
Manitoba Sediment Issues Workshop
November 18-19, 1986
Winnipeg, Manitoba

Re: Workshop Proceedings

In 1984 the Federal Water Resources Branch initiated an evaluation of the Sediment Survey Program in Canada which led, in 1986, to a major review of the Sediment Program in Manitoba by the federal and provincial Water Resources Branches.

The attached report "Proceedings of the Manitoba Sediment Issues Workshop: November 18-19, 1986, Winnipeg, Manitoba" by T.R. Yuzyk is the first of three reports which will arise from this review. The next report will be an extensive compilation and summary of all the available sediment data. The final eport will contain a thorough review of the sediment station network and focus on how the program can best address the issues and data needs in the province. These two reports will be completed early in the new fiscal year.

Your attendance at, and contribution to, our workshop has provided the much needed input to affect changes to our program. As indicated by Mr. Halliday in his opening remarks we are committed to modifying our program to better meet the needs of our data users.

Although large scale changes are not possible in our current economic climate, some shifts will be implemented in 1987-88. Some of these are:

1. a three year bed material sampling program will be initiated on gravel-bed streams in the province;

2. sediment station analysis reports will be completed for approximately two stations per year;

3. station profiles, a document which contains information on the station objectives, sampling program, users, etc., will be prepared for all active stations in 1987-88 and for all discontinued stations over the following two years;

4. long term stations will be discontinued where the data is judged to be sufficient to meet the range of known and anticipated need;

5. resources freed up under 4 will be used to establish new stations or studies;

6. a program to extract hydraulic and morphological data from our existing raw data base and to develop hydraulic relationships will be implemented; and

7. a project will be developed jointly with the Water Quality Branch to link the historical data bases of the two branches, to evaluate the compatibility of the methods used and to analyze the representativity of the data records. It is likely that our station Red River at Emerson will be used for this project.

Once again thank you for attending and contributing to our workshop. I will welcome your continued input and constructive criticism as this program evolves.

Yours sincerely,

R.A. Hale
Regional Chief
Water Resources Branch
Inland Waters/Lands

RAH/cg
att'd.

PROCEEDINGS OF THE MANITOBA SEDIMENT ISSUES WORKSHOP: NOVEMBER 18-19, 1986 WINNIPEG, MANITOBA

by

T.R. YUZYK

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Abstract

It is becoming increasingly apparent that sediment is an important component in the evaluation of a broad range of environmental issues. In Manitoba, sediment data are used in the assessment of numerous water resources projects such as determining the life expectancy of a reservoir, identifying the effects of a diversion scheme or the designing of irrigation and drainage systems. Water quality studies are starting to focus on the role sediment plays in the sourcing, transfer, and fate of many pollutants. In fisheries, increased sediment concentrations impact negatively on the commercial and recreational fish populations in many areas of the province. Even in agriculture, sediment found in streams translates into lost productive soil from farmlands and into increased maintenance costs to irrigation systems.

The workshop brought together over fifty representatives from consulting firms, universities as well as from federal and provincial governments to identify sediment issues and to comment on the existing network of stations. The information obtained from this workshop is being applied by both the federal and provincial Water Resources Branches as part of an evaluation of the Sediment Program in Manitoba.

Résumé

Il est de plus en plus évident que les sédiments constituent un élément important de l'évaluation d'un vaste éventaire de problèmes écologiques. Au Manitoba, les données relatives aux sédiments servent à évaluer de nombreux projets hydriques tels que la détermination du cycle de vie d'un réservoir, l'identification des effets d'un projet de dérivation ou la conception de systèmes d'irrigation et de drainage. Les spécialistes commencent à axer leurs études de la qualité des eaux sur le rôle que jouent les sédiments dans la source, le transfert et le devenir d'un grand nombre de polluants. Quant aux pêches, les concentrations accrues de sédiments ont des incidences néfastes sur les polulations de poissons appréciés tant pour la pêche commerciale que sportive dans maintes régions de la province. Même en agriculture, les sédiments présents dans les cours d'eau entraînent la perte de sols productifs des terres agricoles et l'augmentation des travaux d'entretien requis les systèmes d'irrigation.

L'atelier a réuni plus de cinquante représentants de sociétés d'experts conseils, d'universités ainsi que du gouvernement fédéral et de ceux des provinces venus identifier les problèmes concernamt les sédiments et commenter le réseau actuel des stations sédimentologiques. Le personnel de la Direction des ressources en eau, aux palier fédéral et provincial, appliquent présentement l'information acquise lors de l'atelier à une évaluation du programme, d'étude des sédiments au Manitoba.

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1. Manitoba Sediment Program Review

1.1 Previous Reviews of the Manitoba Sediment Program

In the late 1970s a number of reviews were undertaken which helped to guide and develop what is now the present network of sediment stations in Manitoba (Vitkin and Penner, 1979; Hanson, 1979). These reviews primarily focussed on the engineering needs for data.

To introduce a more multidisciplinary perspective into the sediment program T.J. Day of the Sediment Survey Section initiated a national review. A total of five contracts were awarded, one for each of the Water Resources Branch's five regions, which were aimed at identifying sediment issues and assessing data needs. The Western and Northern Region, of which Manitoba is a part, was awarded to Northwest Hydraulics Consultants Ltd. This review was completed in 1985 and culminated in the report entitled, "Assessment of Sediment Issues and Survey Program in the Prairie Provinces". This report provided considerable insight into generic sediment issues on the prairies and its broad recommendations provided a framework and a focus for a more detailed evaluation of the network and issues in Manitoba.

In 1985 an internal review was undertaken in the Western and Northern Region to provide more specific direction on the network. As part of this exercise a questionnaire was sent to 52 individuals

and 31 responses were received. The responses provided useful, but limited information on the network direction. This information was included in the internal evaluation of the sediment program in the Western and Northern Region (Day, 1986). The report contains thirty-six recommendations on how to improve the program both on a managerial and technical basis.

1.2 Approach Developed for this Review

One of R.A. Hale's goals as the new Regional Chief of the Water Resources Branch in Winnipeg involved undertaking a major review of the Sediment Program in Manitoba. It was also decided that this review should be jointly undertaken, thereby ensuring that both the provincial and federal perspective would be included. T.R. Yuzyk of the Sediment Survey Section was seconded to coordinate the federal perspective, while F. Penner of the Manitoba Water Resources Branch was chosen to represent the provincial interests.

To ensure a data collection program continues to be viable there must be a strong input from the data users and an awareness made of their needs. Questionnaires, although a useful tool, are too passive an approach for obtaining viable feedback on a program. Workshops have been demonstrated (in the Ontario and Atlantic Regions) to be an effective means of obtaining this much needed input. Therefore, a workshop was considered to be an integral part of this evaluation.

The initial phase of the review involved interviewing approximately 20 individuals to assess their knowledge of the existing program and determine if they would be interested in taking part in a sediment workshop. The names of those that were interviewed were primarily derived from the Water Resources Branch mailing list, others names were obtained from the individuals that were interviewed. *Based on these interviews it was apparent that there was considerable interest in the program and the workshop, and many individuals agreed to give presentations.*

The next phase involved organizing the workshop and publishing the proceedings to document the response. Eighty-five individuals were mailed an agenda along with a form requesting general information about themselves and their interests in sediment. A total of fifty-eight of these forms were returned (see Appendix).

The final phase will consist of an extensive review of the entire data base and will focus on summarizing much of the information. The results from this will be used to determine the appropriate sampling strategy and provide further program direction.

1.3 Outputs from this Review

To best address the diversity of concerns and needs it was decided that three individual reports would be produced from this review. This would enable each report to be effectively targeted at a specific audience. The reports will be as follows:

Report 1:

Title - Proceedings of the Manitoba Sediment Issues Workshop: November 18-19, 1986, Winnipeg, Manitoba

Contents- Documentation of the workshop.

Level - Workshop audience

Distributed by - March, 1987

Prepared by - T.R. Yuzyk

Report 2:

Title - A compilation of Sediment Data Collected in Manitoba

Contents- A compilation of all the data collected by the Water Resources Branches. Summary tables and plots of the data will be produced for the 52 active and discontinued stations in Manitoba. The report will also reference other agencies data and reports.

Level - Program Managers, Researchers

Distributed by - May, 1987

Prepared by - F. Penner, T.R. Yuzyk

Report 3:

Title - Manitoba Sediment Program Review

Contents- A review of the data collected at each station will be undertaken to determine if the station is meeting its objectives, the effectiveness of the sampling strategy and what further data are required. The report will focus on how the program should be addressing the issues and how to incorporate the data needs of non-traditional users.

Level - Water Resources Managers.

Distributed by - June, 1987

Prepared by - T.R. Yuzyk, F. Penner.

2. Manitoba Sediment Workshop

2.1 Workshop Program

The day and half workshop was organized into three distinct sessions aimed at addressing specific needs. The first session was an orientation session focussing on the Sediment Survey Program; the second, was a technical presentation session which reflected the make-up of the sediment community in Manitoba, and the third session was a working groups session which was designed to provide feedback on sediment issues and data needs in the province. The specific purposes of each session are outlined below:

1. Orientation Session:

   - to update or familiarize sediment data users with the existing program
   - to provide technical advice on equipment, data collection and interpretation.

2. Technical Presentation Session:

   - to provide a forum for which the sediment community can express their interests and concerns with sediment
   - to bring together people from different disciplines to focus on sediment issues in the province
   - to provide an opportunity for people to become better acquainted with the large number of individuals and organizations working with sediment data.

3. Working Groups Session:

   - to focus on major disciplines and their concerns and needs pertaining to sediment
   - to determine what the issues are within each group, how significant they are, and how to address them.

2.1.1 Orientation Session

The afternoon of the 18th was scheduled as the orientation session. The session consisted of five presentations and six displays which dealt with various aspects of the Sediment Program. They were as follows:

1. Presentations:
    1. Introduction - Bob Hale
    2. Sediment Survey Program: National Focus - Terry Day
    3. Manitoba Sediment Program: Review - Ted Yuzyk
    4. Manitoba Sediment Program: Status - Ian McLaurin
    5. Equipment, Procedures and Data - Morley Cashman

2. Displays:
    1. Sediment Equipment - Clare Bowden
    2. Interpretative Sediment Reports - Terry Day
    3. Morphological and Special Studies - Ted Yuzyk
    4. Sediment Data Publications - Morley Cashman
    5. Water Survey of Canada Programs - Ian McLaurin
    6. Soil Erosion Risk Maps for Manitoba - Crawford Jenkins

2.1.2 Technical Presentation Session

The technical presentation session was made-up of seven presentations which were selected to provide a broad overview of sediment-related work being undertaken in Manitoba (see agenda). A copy of the opening remarks and abstracts reflect the multidisciplinary approach adopted towards this workshop.

AGENDA
NOVEMBER 19, 1986

TIME: 8:45 Opening Remarks:
Ted Yuzyk (Chairman)
Terry Day (Sediment Survey Section)
Bob Halliday (Inland Waters/Lands)

9:00 "An Overview of the Sediment Network in Manitoba"
Frank Penner (Manitoba Water Resources Branch)

9:20 "Sediment Station Analysis: Saskatchewan River at The Pas 05KJ001"
Terry Day (Sediment Survey Section)

9:40 "Basin-Scale Suspended Sediment Investigations"
Peter Ashmore (University of Saskatchewan)

10:00 Coffee

10:20 "Erosional Concerns Along the Manitoba Escarpment"
Bob Newbury (Fisheries and Oceans)
Allan Chapman (Prairie Farm Rehabilitation Administration)

10:40 "Effects of Changes in the Sedimentary Regime of Southern Indian Lake"
Greg McCullough (Fisheries and Oceans)

11:00 "Use of Sediment Load Data in Irrigation and Drainage"
Crawford Jenkins (Manitoba Agriculture)
Frank Penkava (University of Manitoba)

11:20 "Fisheries Concerns with Sediment"
Marc Gaboury (Manitoba Fisheries Branch)
Drew Bodaly (Fisheries and Oceans)

11:40 "Water Quality Concerns with Sediment"
Val Chacko (Water Quality Branch)
Dwight Williamson (Environment and Workplace Safety and Health)

12:00 LUNCH

OPENING REMARKS

Mr. R.A. Halliday, Regional Director, Inland Waters/Lands of Environment Canada opened the workshop by pointing out that the Sediment Survey Program of the Water Resources Branch is twenty-five years old and that it is now time to seek adjustments and new focus. Mr. Halliday continued to say:

"As a data collection agency, the Water Resources Branch has been effective but now it must adapt to the demands of an information era where water resource managers must understand the state of the resource and the environment. The traditional sectoral approach to water management is no longer effective and this fact is amply demonstrated in the emergence of non-traditional data users.

Today an integrated approach is required. The entire basin unit must be considered rather than single points within a basin. Also, interdisciplinary solutions must be sought. These are especially relevant in the consideration of land/water interactions.

Furthermore, Inland Waters/Lands is pursuing a more active role in influencing the direction and content of water resources activity. Part of this attitude is pursuing a more aggressive policy in communicating with clients and marketing the Directorate's capabilities.

Finally, with the present fiscal situation in government being one of "value for money, more for less" water resource experts and managers must find ways to channel scarce resources effectively."

Mr. Halliday concluded by expressing Water Resources Branch's commitment to act on the results of the workshop and in particular to review these with the province of Manitoba.

"AN OVERVIEW OF THE SEDIMENT NETWORK IN MANITOBA"

by

F. Penner

Manitoba Water Resources Branch

Abstract

A number of case studies undertaken by the Manitoba Water Resources Branch dealing with such matters as: reservoir sedimentation, shoreline erosion and stream morphology will be highlighted to show the use and importance of sediment data.

A brief overview of the sediment program will be presented along with the strategy the province has adopted towards the collection and review of these data. Concerns with various aspects involving the collection and interpretation of sediment data will also be raised. Finally, the adequacy of the existing program to address fisheries, water quality, etc. issues will be focussed upon.

SEDIMENT STATION ANALYSIS:
SASKATCHEWAN RIVER AT THE PAS
05KJ001

by

T.J. Day

Sediment Survey Section

Abstract

A thirty year (1954-1984) record of sediment data for this station has recently been reviewed by Northwest Hydraulic Consultants Ltd. as one of a series of studies of long term stations. The data were assessed in terms of upstream conditions and the adequacy of the data base to document the regime.

The analyses demonstrate that the suspended sediment regime is well documented for the period 1963 to 1984 and that sufficient data now exist. Prior to 1963, while only partial records exist, it was possible to determine loadings.

The upstream sediment budget analyses indicate that before 1963 when the upstream sediment inflow was cut off (primarily due to the Squaw Rapids project), approximately 5 Mt/a of sediment were deposited in Cumberland Lake. The impact of this loss of annual sediment is unknown.

"BASIN-SCALE SUSPENDED SEDIMENT INVESTIGATIONS"

by

P. Ashmore

University of Saskatchewan

Abstract

Sediment Survey data can be used to investigate suspended sediment transport in drainage basins of various sizes within a region. Within the major drainage basins there are data for a sufficient number of sub-basins to give a regional picture of suspended sediment load and concentration. It is possible to derive information on sediment yield, source areas, annual regime of concentration and load, temporal and spatial variability of load and concentration, correlation between discharge and suspended sediment transport characteristics, duration curves and the significance of high magnitude events.

An investigation of this kind was carried out on the Saskatchewan River basin upstream of The Pas, utilizing all the available data. Suspended sediment is derived mainly from the western Plains portion of the basin where concentrations and yields are greatest. Reservoir development now prevents much of this sediment from reaching Cedar Lake; mean annual load at The Pas has been markedly lower since

1963 compared to estimates made in the late 1950s and early 60s. The large prairie rivers with mountain sources have more conservative values for temporal variability, and less skewed distributions of annual and daily load and concentration than do the smaller eastern slopes and prairie basins. Estimates of mean annual load can be made from miscellaneous data, but are unreliable.

"EROSIONAL CONCERNS ALONG THE MANITOBA ESCARPMENT"

by

R. Newbury

Fisheries and Oceans

and

A. Chapman

Contractor (PFRA/Turtle River Conservation District)

Abstract

The Manitoba escarpment is divided into four major segments by proglacial river valleys. The segments, the Pembina, Riding, Duck, and Porcupine "Mountains", extend from the Canada/US border, to The Pas, Manitoba. Geologically, the escarpment is composed of two major components; an underlying layer of soft friable Cretaceous shales varying in thickness from 30 to 300 m, and an overlying layer of bouldery glacial soil, varying in thickness from 10 to 40 m. The face of the escarpment is dissected by numerous stream valleys, many of which terminate in alluvial fans of loosely consolidated shale fragments.

Between 1920 and 1950, drainage canals were constructed from the regional drainage network to intercept the escarpment streams. Where the canals traversed the fan areas to join with the escarpment streams, severe downcutting and headwater erosion occurred, increasing the stream sediment loads by as much as 5X. The coarser fraction of the re-transported materials moved only a few kilometres downstream before

re-depositing in the canals while the suspended sediments travelled through the drainage network to Lake Dauphin and Lake Manitoba. The infilled canals require repetitive and expensive reconstruction to prevent flooding of adjacent farmlands following spring snowmelt and intense rainstorms on the escarpment.

In 1980, experimental gradient control structures were constructed in the upper reaches of the Wilson Creek alluvial fan. Erosion has stopped in these reaches and the channel has stabilized with floodplain vegetation. Consequently, further sites for gradient control dams are being located in other escarpment streams in a PFRA funded project. At the same time, data are being gathered on the natural geometry of escarpment streams for use in experimental canal rehabilitation works below the alluvial fans in reaches where fish spawning is practical. The rehabilitation works are being constructed jointly by the Manitoba Water Resources and Fisheries Branches and the Habitat Heritage Corporation (M. Gaboury).

"EFFECTS OF CHANGES IN THE SEDIMENTARY REGIME OF SOUTHERN INDIAN LAKE"

by

G.K. McCullough

Fisheries and Oceans

Abstract

The Southern Indian Lake impoundment is discussed as an example where small changes in very low concentrations of suspended sediment and greater changes in sedimentary processes (which could not be identified by suspended sediment sampling alone) caused important ecological changes.

Shoreline erosion due to impoundment of Southern Indian Lake increased sediment supply to the lake by 15X the natural Churchill River influx of 250,000 tonnes.y^{-1}. Although the bank materials are more than 60% clay, they were not completely disaggregated by wave action, and more than 80% were redeposited within 300 m of shore in 2 to 10 m depths. Thus, total sediment load in the water column increased by just over 200,000 tonnes, and suspended sediment concentrations have only trebled, from about 3-5 g/m^3. Almost 50% of this suspended sediment was less than 0.001 mm in diameter.

Nonetheless, these changes in the sedimentary regime have triggered significant ecological reactions. Primary production, which increased in isolated small bays with negligible shoreline erosion, was unchanged in the main body of the lake because sediment-induced light limitation cancelled the effect of a nutrient influx due to flooding of vegetation. Reduced transparency caused decreased predation of the zooplankton community, and led to changes in the species structure of the community. Local decreases in benthic invertebrate populations resulted when eroded bank sediments were redeposited over nutrient-rich nearshore substrates. Most significantly to the local economy, a serious decline in the fishery catch per unit effort resulted from a redistribution of whitefish stocks that was attributed to decreased visibility, which would have inhibited both feeding and schooling. In situ experiments showed that the high nearshore sedimentation rates reduced whitefish egg survival, and gave concern for the long term abundance of whitefish in Southern Indian Lake.

"USE OF SEDIMENT LOAD DATA IN IRRIGATION AND DRAINAGE"

by

C. Jenkins

Manitoba Agriculture

and

F. Penkava

University of Manitoba

Abstract

With the increasing refinement of planning and designing of irrigation and drainage systems more information on the properties of the water used or discarded becomes necessary.

In irrigation the amounts of sediment load in the water determines the rate of canal and reservoir siltation and hence the frequency of maintenance and wear on pumps, pipes and sprinkler equipment. In drip irrigation it is one of the most important water quality factors affecting the design of the system. It is crucial to making decisions on the need and the type of water purification by sedimentation, silt trapping or filtration.

In drainage water, sediment loads indicate the degree of erosion of soil from the watershed and indicate the need of erosion control measures. As soil conservation becomes one of the most urgent goals in agriculture, sediment load monitoring in streams will be very helpful.

"FISHERIES CONCERNS WITH SEDIMENT"

by

M. Gaboury

Manitoba Fisheries Branch

D. Bodaly

Fisheries and Oceans

ABSTRACT:

Sedimentation of silts and clays in lakes and rivers has had detrimental effects on the survival of fish eggs, on fish community composition, and on quality and quantity of fish habitat. Recent studies have investigated the relationship between sedimentation and the survival of eggs to hatch. A field experiment conducted in 1983 showed that the amount of silt and clay deposited in the Valley River (Dauphin Lake) was negatively correlated with walleye egg survival. In another experiment it was shown that higher suspended sediment levels in Southern Indian Lake (SIL) after flooding have resulted in greater sedimentation and consequently significantly lower whitefish egg survival. Also the behaviour of whitefish was affected by increased turbidity. Movements of whitefish out of some regions of SIL may have been hastened by the decrease of light penetration, since day time light intensities near lake bottom were now below those required for effective schooling and feeding.

Within Agro-Manitoba physical alteration of streams through channelization and diversion, and expansion of drainage network through ditching have promoted erosion and sedimentation. The effects of sedimentation are clearly evident in the Dauphin Lake watershed where lake and stream spawning sites and nursery areas have been negatively impacted upon, large deltas have been formed at stream mouths, and average lake depth has decreased. Also siltation of fine silts and clays has resulted in changes to the composition of the fish community. The dominant fish species have shifted from those which prefer clear and/or vegetated waters (i.e. walleye, sauger and goldeye) to less valuable ones which are tolerant of high turbidity and silty lake bottoms (i.e. carp and suckers).

"WATER QUALITY CONCERNS WITH SEDIMENT"

by

V. Chacko

Water Quality Branch

and

D. Williamson

Environment and Workplace Safety and Health

Abstract

Federal Perspective:

Sediment chemistry has gained recognition in recent years as the concern for contaminants in the aquatic environment developed and with the knowledge that many contaminants are associated with the sediments. Issues concerning aquatic quality primarily relate to the role of sediment as a holding sink, source of future release, and as a transporter of pollutants. The role of sediment as a holding sink and its mobilization and bioavailability are reasonably well understood. But the role of sediment as a transporter of pollutants is not well understood. Contaminants such as organochlorines and heavy metals are absorbed or adsorbed to the particulate phase and the concentration in the particulate phase generally is higher than in the dissolved phase. But it does not mean that most of these pollutants are transported in the particulate phase. Earlier studies also have shown that most of the

contaminants are tied to the smaller particles. A knowledge of the particle size and its composition is essential in correctly assessing water quality.

There are two limitations in working with sediment. One is the generally poor detection limit as reported by an analyst and the second one is the collection of a representative sample. Both of these areas require further development. It is also known that while an analyst is looking at a parts per billion range a collector at best is looking a parts per hundred range.

To gain a better understanding and to assess the Water Quality Branch sediment sampling procedure a study was conducted. In this study, the current WQB method was compared with the Water Resources Branch sediment sampling method. The results showed that both methods are comparable and thus acceptable.

Provincial Perspective:

Water quality management and monitoring responsibility within Manitoba are divided between the Manitoba Department of Environment and Workplace Safety and Health, and the Water Quality Branch, Environment Canada. Manitoba is responsible for such activities within all intra-provincial waters, whereas Canada is responsible for such activities within international, inter-provincial and other water bodies within the province of federal interest.

Water quality is monitored at various locations to assess the quality of this resource in support of our respective responsibilities. This assessment includes a network of water chemistry monitoring sites, a network of biological monitoring sites, as well as complementary intensive site-specific localized studies. An integral part of this assessment strategy includes the examination of sediment compartments for trace metals, organics and nutrients. Our concerns include the role played by sediment in the transport, mobilization and storage of these materials as well as the possible impairment of certain water uses by the physical presence of increasing suspended sediment concentration.

2.1.3 Working Groups Session

In the afternoon of the 19th the workshop members selected a group to attend which related the most to their particular background. There were four groups from which to choose:

Group	Group Leader
Agriculture	Crawford Jenkins
Fisheries	Bob Newbury
Water Quality	Dennis Gregor
Water Resources Engineering	Frank Penner

Each group was given a list of generic (13 in total) questions which were aimed at helping them focus their discussion. The group leaders were also told that they should deviate from the list if they felt that other more appropriate questions would generate more input.

The groups were given one hour for discussion and recording of their ideas. The workshop members then reassembled and each group leader was given 15 minutes to present the group's findings. The questions and responses from each group are as follows:

QUESTION:	AGRICULTURE:	FISHERIES:	WATER QUALITY:	WATER RESOURCES ENGINEERING:
1. What do you feel are the important issues relating to sediment?	- sediment sourcing - deposition of sediment on the fields and off the fields (basin delivery) - how sediment affects the water quality for domestic and agricultural uses - pollutant (pesticides, fertilizers) load attached to the sediment	- ecological effects (nutrients, toxics, light penetration, physical - socio-economic (impact on commercial and recreational fishing)	- sediment quality (metals, toxics and nutrients associated with sediment) - assessing the impact of sediment and/or associated contaminants to water use	- the amount of useable data - regional and temporal coverage of sediment data - sediment as a contaminant carrier - sediment as it affects and is affected by hydraulic structures
2. Where in the province are these issues important?	- Manitoba low lands for wind erosion and depositional problems - Manitoba Escarpment for water erosion and depositional problems - Manitoba Uplands for wind and water erosion and depositional problems	- Lake Winnipeg - Southern Indian Lake and diversions - Agro-Manitoba region - Assiniboine and Red River Systems	- all areas where water chemistry is important: Assiniboine River, rivers on the plains and near mining areas	- Manitoba Escarpment - agricultural areas - where deltas are being formed

QUESTION:	AGRICULTURE:	FISHERIES:	WATER QUALITY:	WATER RESOURCES ENGINEERING:
3. How do you approach these issues - monitoring? studies? both?	- Manitoba low lands: soil risk maps, isolated studies, soil and water management strategy, four Conservation Districts - Manitoba Escarpment: Headwater Storage Study, Newbury/Chapman Study, food projects, two new Conservation Districts, soil and water management strategy - Manitoba Uplands: One Conservation District, two proposed, soil and water management strategy	- site specific studies of impacts using several disciplines - land use planning criteria and controls - comparative regional studies - process studies	- monitoring and studies	- limited monitoring, mostly site specific data - physical processes analyzed using whatever data exists

QUESTION:	AGRICULTURE:	FISHERIES:	WATER QUALITY:	WATER RESOURCES ENGINEERING:
4. What types of data do you generally require? (i.e. concentration, particle size, load, cross section)	- concentration - sediment source - sediment quality data	- sediment (concentration, particle size, texture, minerology, bed load) - sedimentary processes - morphological - chemical (toxics/nutrients) - coring for historical analysis	- concentration - loads - cross-sectional characteristics - analytical chemistry - particle size	- concentration - sediment loading - budgets - chemistry of sediment - particle size of bottom and suspended sediment - hydraulic data
5. Where do you go to obtain these data? (collect your own, a data base)	- need site specific information therefore Sediment Survey data rarely appropriate - collect our own	- collect our own - interpret from air photos, remote sensing - Sediment Survey data sometimes if dealing with larger streams	- collect our own - use Sediment Survey data for background information	- primarily Sediment Survey data - if site specific then we collect our own

QUESTION:	AGRICULTURE:	FISHERIES:	WATER QUALITY:	WATER RESOURCES ENGINEERING:
6. If you do check the Sediment Survey data base - do you find it useful? Are the data you are looking for generally there? Are the data accessible?	- no comment	- not useful - data not usually available at sites being studied	- use publications and data base	- very useful - access normally good - some problem obtaining raw data - find the processed data valuable
7. When you collect your own data, what sampling strategy do you use? (i.e. grab or depth integrated, umber of verticals, number of samples, reach vs. cross section)	- no comment	- centrifuge - sediment traps on spawning beds - grab sample from the bed - remote sensing data - coring - repeat surveys	- grab sample - single sample, sometimes enhanced sampling (a number of samples) - monitoring (once a month) - studies will vary from periodic to continuous sampling - use both reach and single point approach	- seldomly collect own - depth integration of a single vertical - seasonal period only

QUESTION:	AGRICULTURE:	FISHERIES:	WATER QUALITY:	WATER RESOURCES ENGINEERING:
8. What period of the year are you most concerned with? (i.e. spring (freshet), summer, fall, full year)	- March - October - growing season	- incubation period (spring) - growing period (summer)	- spring, summer and fall	- freshet only - all year round for special studies
9. What types of equipment do you use?	- no comment	- what ever is appropriate	- standard water quality equipment - centrifuge	- centrifuge - automatic sampler - turbidity meters
10. What standards do you use for collecting these data?	- no comment	- depends on funding, geographical setting - 2 micron filter for suspended sediment	- Water Quality Branch standards - limited standards available	- Sediment Survey standards

QUESTION:	AGRICULTURE:	FISHERIES:	WATER QUALITY:	WATER RESOURCES ENGINEERING:
11. Where do you go for advice on equipment and sampling procedures?	- no comment	- literature (USGS compilation of stream characteristics and resistance) - university - Sediment Survey - inspiration	- colleagues - Water Quality Branch manuals	- Sediment Survey Section
12. How successful do you find cooperative studies?	- terms of reference very important - gaining in popularity	- cooperative studies worthwhile but depends on participants - problems arise with different periods of commitment, different funding priorities	- need more cooperation with the Sediment Survey at the implementation level	- involvement with cooperative studies have been successful - benefit to all to buy sediment service from Sediment Survey Section

QUESTION:	AGRICULTURE:	FISHERIES:	WATER QUALITY:	WATER RESOURCES ENGINEERING:
13. Do you see a continuing need for workshops of this type? Should an advisory group be formed?	- very important	- advisory group or consultative protocal needed for fisheries input on: station location; types of data, timing cooperative studies	- maybe a higher level needed to get decisions implemented - a group such as this is useful if it addresses specific concerns	- workshop should meet every 3-5 years - external review advisory group should meet every 2-3 years

3. Issues and Concerns with Sediment

3.1 Agriculture

Agro-Manitoba comprises an area of 52,600 square kilometres of the southern portion of the province. Sediment loads in the streams here are relatively high because of the readily available supply of sediment coming from the farmlands. Approximately 15% of this area is highly susceptible to erosion from runoff. Another 15% is exposed to severe wind erosion which can result in soil being deposited into drainage ditches and streams.

There have been a number of changes in farming practices that are responsible for the increase in sediment being contributed from agricultural areas. Some of the changes are: increased summer follow, due to poor economic conditions, is leaving more land open to erosion; more land is being sown into non-cereal crops which provide little after crop residue and hence protection; sloughs and other wetlands are being drained to provide more land in some areas, resulting in sediment-laden water flowing directly into streams and lakes (C. Jenkins).

The agricultural perspective for years only focussed on the on-farm impacts due to erosion and sedimentation. Soil degradation is the main concern because it directly affects the land productivity, either through removing valuable land from production or by making it

less fertile through the removal of top soil. Other areas where sediment has had a negative impact on farm operations is through increased costs in the maintenance of pumps, pipes and sprinkler systems (F. Penkava). Added costs have also been incurred through the maintenance of drainage ditches and intake structures that have silted in.

In recent years, however, more attention is being paid to the off-farm impacts. Soil eroding from farmlands for example carry pollutants such as pesticides and fertilizers into the aquatic environment. This, in turn, affects resources (i.e. commercial and recreational fisheries) and also the quality of the water for domestic and industrial usage. Sediment eroding from the fields comes to be deposited in municipal drainage ditches, adding to maintenance cost; in reservoirs it reduces the reservoir's economic life expectancy; and, along navigable waterways it results in expensive dredging costs. It is becoming apparent that these impacts must be assessed in the benefits of developing a conservation strategy for the agricultural sector.

In agriculture, sediment information is derived in a number of ways, such as through collecting data from small erosion plots or through Cesium-137 studies. The most widely used approach involves using an empirical equation (Universal Soil Loss Equation) for calculating soil erosion. The equation incorporates the use of six factors: runoff, soil erodibility, slope length, slope steepness, vegetation cover and management practices. There still, however, is the problem of taking

into account drainage basin delivery. That is why in Manitoba the approach has been to develop a soil risk map which is based solely on physical soil properties and physiography.

Generally sediment loadings are useful, however the Manitoba network of sediment stations is of limited value because of the sparse coverage and most of the stations are concentrated on relatively large streams. To be able to effectively monitor sediment sources and changing land use practices these data will have to be collected from a relatively small watershed in order to be manageable (C. Jenkins).

3.2 Fisheries

Increasing sediment loads in rivers and lakes due to changing agricultural practices (C. Jenkins), land drainage schemes (R. Newbury) and river diversions (G. McCullough) have had significant detrimental effects on both the commercial and recreational fisheries in Manitoba Southern Indian Lake (G. McCullough) and Lake Daulphin (M. Gaboury) are two well documented cases that show the negative impact that sediment has had on the fish populations. Other areas that have been identified as where sediment is impacting upon fish populations are Lake Winnipeg, Assiniboine River, Red River and many of the streams draining the Manitoba Escarpment and the Agro-Manitoba region.

Higher than normal suspended sediment concentrations can affect fish in a number of ways, such as by: inhibiting their oxygen intake

(clogging gills); reducing the light penetration and thereby affecting schooling and feeding practices; or indirectly, reduced light levels can inhibit photosynthesis by the aquatic plants, which in turn can disrupt the whole aquatic ecosystem. Nutrients and pollutants transported by the sediment can affect the fish directly, or can cause a lake to become eutrophic thus making it an unsuitable environment.

As the suspended sediment deposits along watercourses and in lakes it can settle on fish eggs and cause suffocation, or deposit on spawning beds and change the bed composition so it is no longer suitable for spawning. In cases where deposition is quite significant it can restrict passage and alter migration patterns.

Changing the morphological and hydraulic characteristics of streams and rivers through diversions, drainage schemes and other in-channel works can have an adverse effect on the local fish population (M. Gaboury; R. Newbury). In many cases the channel conditions are changed to the extent that the fish no longer find the habitat conducive to spawning and rearing of fry. Stream rehabilitation projects, such as are being undertaken on the Mink and Valley Rivers are attempting to reconstruct a suitable environment. As this approach is gaining in popularity the need for morphological data and hydraulic relationships for various drainage basins will be required.

As limited data exists regarding sediment threshold limits of the various species of fish found in Manitoba, suspended sediment data

are not as useful as it could be (J. O'connor). The complexities involved with interpreting the sediment data as it relates to the sediment regime has also been a deterent for using these data in riverine studies. However, suspended sediment data are important in deriving sediment budgets for sinks, such as a lake (G. McCullough).

Even though increased sediment loadings have been attributed to various water resources projects, which have adversely affected the fish population, there have been no charges laid in Manitoba (D. Bodaly). Statutory Regulations such as found in the Fisheries Act which relate to discharge of deleterious substances (i.e. sediment) have not been invoked in Manitoba as in many parts of Canada. This in turn has given the misleading impression that sediment has not been a concern.

3.3 Water Quality

Sediment is important to water quality for its role in the sourcing, transfer and fate of contaminants such as toxics and metals. Also the nutrient level associated with the sediment is another important consideration. Finally, sediment itself is one of the parameters used to determine the consumptive value of water.

The Water Quality Branch has ten sites it monitors which are located near boundaries on international and interprovincial rivers: Churchill, Nelson, Hayes, Manigotatan, Red, Roseau, Souris, Pembina,

Saskatchewan and Cochrane (V. Chacko). The province on the other hand is primarily concerned with the Red and Assiniboine river systems; however, sampling is also conducted on the Winnipeg, Souris and Saskatchewan Rivers, and in the northern part of the province near major mining sites (D. Williamson).

Sediment information is collected in a number of ways for water quality analyses. For instance, non-filterable residue (mg/L) which is one parameter obtained from the standard analyses is considered synonymous with suspended sediment. To evaluate the attached contaminant load to the sediment it is necessary to collect a sizeable amount of suspended sediment; in such cases centrifuging on site is conducted. This type of data is presently being collected at two sites in Manitoba, namely the Red River at Emerson and the Souris River at Coulter stations (V. Chacko). The province's program for collecting attached contaminant information involves collecting and analyzing bed material samples at many of their southern stations (D. Williamson).

In recent years many studies have shown that sediment is a more suitable medium than water for assessing the presence of many of the contaminants. There still are many fundamental questions that need to be addressed to understand the role sediment plays, such as: what particle size class does a particular contaminant have an affinity to; what bonding and release mechanisms are involved with different contaminants; and, what are the contaminant levels that can be expected to be

associated with the sediment fraction? There are also the problems involved with the collection and interpretation of the results which add to the complexity of using sediment data.

Collecting a large enough sample of suspended sediment, so as to be able to perform the analysis, can be a problem. During freshet sediment concentrations are sufficiently high that a relatively large sample, normally obtained by combining a number of bottles, may be acceptable. However, most of the time sediment concentrations are in the order of hundreds of mg/L in which case centrifuging at a site is the only appropriate way to obtain a large enough amount of sediment. The time and expense associated with the method are limiting factors for its use.

Another way to get enough sediment is to collect a bed material sample. Although this will provide information on the fate of certain contaminants, it is not that useful in assessing what is being transported in the river system.

An understanding of the physical processes of erosion, entrainment, transport and deposition of sediment will grow in importance in Water Quality studies as the significance of sediment becomes more widely accepted. The data collected by the Water Resources Branch will increase in value once evaluations have been made regarding the differences in sampling methodology (i.e. isokenetic vs. grab),

laboratory procedures (i.e. filter sizes) and terminology (particle size range for clays).

3.4 Water Resources Engineering

High sediment transport rates in streams draining the Manitoba Escarpment are an important consideration in the design of headwater ponds and erosion-control structures. In Agro-Manitoba sediment is a factor when installing water intake structures or undertaking land drainage schemes. In the northern part of the province the emphasis is on environmental impact assessment of large-scale water resources projects such as diversions and impoundments.

The network of sediment stations in Manitoba has developed on the basis of addressing the concerns of numerous water resources projects. The network currently comprises twenty-one active stations and thirty-one discontinued sites (Environment Canada, 1987). The data have been used for addressing such concerns as reservoir sedimentation (i.e. Lake of the Prairies), bank erosion (i.e. Churchill River Diversion), bed degradation (i.e. Assiniboine River), diversions (i.e. Red River Floodway), and delta formation and lake sedimentation (Lake Daulphin) (F. Penner).

From an engineering perspective the concerns with sediment pertain primarily to the quality and quantity of the data. Because of

the relative small size of the network, in many cases data are rarely available for addressing such site specific concerns as pipeline crossings and water intakes. In these cases interested parties have to collect their own data, however, as individual organizations get involved in collecting their own, the quality is questionable and the data availability is restricted. Reviewing such data and incorporating it into the Sediment Survey data base would be very useful and help expand the spatial coverage of the network.

Retrieving data from the Sediment Survey data base is normally not a problem, unless it is the raw data which are required. Interpreted data outputs such as shown in the sediment station review reports are useful tools for providing a good summary of the sediment data. Sediment budgets of drainage basins, as done in the case of the Saskatchewan River system is an important extension of knowledge which then can be applied to various studies and therefore should be pursued.

4. Implications for Sediment Monitoring and Studies in Manitoba

4.1 Federal and Provincial Sediment Monitoring Program

Most data users find the existing sediment station network coverage inadequate to meet their needs. There are however two cost-effective ways in which to improve this situation. One way involves increasing the size of the network by expanding the number of miscellaneous stations. These stations are considerably less expensive to operate than full time or seasonal stations yet, in most cases, they provide the level of information required. The other way to improve the coverage involves incorporating data collected by other agencies into the data base. *Therefore to improve the network coverage it is recommended that both of these approaches be actively pursued.*

The program must also expand its data collection strategies and technology. More emphasis needs to be placed on collecting the required data using the most appropriate method. Sampling strategies must be more versatile and focus on collecting the appropriate amount of data. For instance, long term stations (i.e. records $\geq$ 15 years) have proven to be of limited value. Equipment such as automatic samplers and turbidity meters, for example, need to be incorporated into the data collection capabilities of the program. *It is therefore recommended that the program become more flexible in the design of sampling strategies and incorporating current technology.*

A majority of the data users also feel that their needs are not given proper consideration nor is the program flexible enough to address their requirements. *To overcome this concern it is recommended that demonstration projects be established with each of the major non-traditional user groups and be aimed at addressing their particular need for sediment data. To further improve communications with the users it is recommended that an advisory group be formed for the purposes of providing a mechanism to ensure that the major user groups needs are represented. It is also recommended that workshops, such as this one, be conducted on a periodic basis to provide information transfer to and from the sediment community.*

The program must also expand its interpretive capabilities if it is to successfully address emerging sediment issues. Interpretive reports on sediment budgets of various drainage basins would be a valuable extension of the data base information and necessary input for many environmental studies. Morphological studies should also be pursued to provide a better understanding of sediment transport and channel geometry. *It is therefore recommended that the program expand its data interpretation capabilities so that it can effectively undertake analyses and provide feed back on sediment issues.*

4.2 Agriculture

The off-farm impacts from sediment are widespread. There is an urgent need to identify and quantify these impacts. *For instance,*

studies are needed to determine the level of contaminants transported by the sediment originating from agricultural areas. Other studies are required to assess the physical impact that this sediment will have on the aquatic environment. There is a need to undertake a comprehensive study to identify these numerous off-farm impacts, expecially so they can be properly included in any cost-benefit analyses.

There is also the need for technical studies to evaluate the extent to which sediment is being eroded from farmlands. *Small-scale studies are required to provide data concerning land use practices and erosion control measures.*

4.3 Fisheries

In the province, fisheries personnel are involved in many stream rehabilitation projects. These projects are attempting to reconstruct a suitable habitat for the more valuable species of fish. Hydraulic relationships which are used to design these projects are seldom based on local data. *Therefore, since these relationships are so important in the design of these projects, a study should be undertaken to generate and compile this information from the gauging data available from the WSC data base.*

It is not well understood how changes in the sediment regime will affect fish and egg survival. Very little physical data exists on the concentration levels of sediment that various species of fish will

tolerate. *Studies need to be conducted to document impacts on fish resulting from changes in the sediment regime and compile data on concentration levels that fish will tolerate.*

4.4 Water Quality

The Water Quality Branch collect sediment data which it refers to as non-filterable residue (NFR) at most of it sites. It has been questioned whether these data are comparable to the sediment data collected by the Water Resources Branch. In Manitoba, there are two sites where an extensive amount of data have been collected by both agencies. The stations are the Red River at Emerson and the Sources River at Coulter. *It is recommended that an evaluation of the sediment data collected by these two programs be jointly undertaken for one of these stations. An extension of this study would be to link the contaminant level associated with the sediment to the sediment regime to derive contaminant loadings. More studies are needed to identify the different contaminants that are transported by the sediment.*

4.5 Water Resources Engineering

For engineers, the concerns with sediment pertain to the quantity and quality of the data. The station network coverage was cited as being a major limitation, Recommendations in section 4.1 address this matter. *More emphasis however needs to be placed on evaluating the quality of the data and informing users of the accuracies that can be expected when using different types of equipment, sampling strategies and interpretation techniques.*

References

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Hanson, D.G., 1979. Review of Manitoba Sediment Program, Inland Waters Directorate Internal Report, Environment Canada, Winnipeg, 12 p. + app.

Northwest Hydraulic Consultants Ltd., 1985. Assessment of Sediment Issues and Survey Program in the Prairie Provinces, Prepared for Inland Waters Directorate, IWD-HQ-WRB-SS-85-5, Environment Canada, Ottawa, 110 p. + app.

Vitkin, N. and Penner, F., 1979. 1979 Review of Suspended Sediment Sampling Program in Manitoba, Manitoba Water Resources Branch, Winnipeg, 21 p. + app.

APPENDIX

INDIVIDUALS' INFORMATION

NO.:	NAME:	TELEPHONE NO.:	TITLE:	MAILING ADDRESS:	INTERESTS:
1.	Dr. Peter Ashmore	(306) 996-5658	Assistant Professor	Geography Department University of Saskatchewan Saskatoon, Saskatchewan S7N 0W0	- Sediment transport processes Sediment supply to stream networks - Alluvial channel morphology - Interested in potential application to environmental and engineering problems
2.	Gary Beckstead	(403) 266-1135	Senior Engineer	Hydrocon Engineering (Continental) Ltd. #526 510 5th St. S.W. Calgary, Alberta T2P 3S2	- Reservoir sedimentation - Streambed degradation - Sediment yields from natural and disturbed basins - Modelling of sediment production, transport and deposition at surface mine sites
3.	Dr. Drew Bodaly	949-5218	Research Scientist	Freshwater Institute 501, University Cr. Winnipeg, Manitoba R3T 2N6	- Fish/sediment interactions - Sedimentation effects on spawning and fish eggs survival - Effects of suspended sediment on fish behaviour and feeding - Programs relating to sediment
4.	Brian Bodnaruk	786-8751	Hydraulic Engineer	Acres International Ltd. 6th Floor - 500 Portage Ave. Winnipeg, Manitoba R3C 3Y8	- Assessment of impact of hydraulic structures on rivers - Reservoir siltation - Streambed degradation - Channel designs
5.	Dennis Brown	945-7033	Head, Water Standards and Studies Section	Environment and Workplace Safety and Health Box 7, Building 2 139 Tuxedo Avenue Winnipeg, Manitoba R3N 0H6	- Sediment as it relates to impairment of water use for domestic consumption, aquatic life, wildlife and recreation - Suspended sediment as a transporter of contaminants - Bottom sediment as a sink for contaminants

NO.:	NAME:	TELEPHONE NO.:	TITLE:	MAILING ADDRESS:	INTERESTS:
6.	Greg Bruce	447-2139	Manager	Turtle River Watershed Conservation District Box 449 Ste Rose du Lac, Manitoba ROL 1S0	- Sediment plugging drains - Sediment loads - Sediment effects on fisheries - Erosion from unstable areas - Water quality
7.	Bob Bute	477-5381	Manager, Civil Engineering Division	Reid Crowther and Partners Ltd. 1150 Waverley Street Winnipeg, Manitoba R3T 0P4	- Impact of sediment deposition on farmland, particularly as it affects crop production - Sediment transport and deposition in river systems
8.	Morley Cashman	(819) 953-3681	Sediment Standards Officer	Sediment Survey Section Environment Canada Ottawa, Ontario K1A 0E7	- Standarizing methods, reviewing sediment data and data computations - Writing office computation manuals and field sampling techniques - Evaluating sediment data
9.	Rick Carson	786-8751	Head, Hydraulic Department	Acres International Ltd. 6th Floor - 500 Portage Ave. Winnipeg, Manitoba R3C 3Y8	- Assessment of impact of hydraulic structures and bridges on sediment movement in rivers - Methods of reservoir desilting
10.	Val Chacko	949-5035	District Resource Officer	Water Quality Branch 133-501 University Cr. Winnipeg, Manitoba R3T 2N6	- Studies that are conducted to characterize sediment in the fluvial system - Monitoring of various pollutants in the particulate phase - Interpreting sediment data
11.	Nick Chapin	(403) 292-5313	Area Engineer	Water Resources Branch Room 854-220 4th Ave. S.E. Calgary, Alberta T2P 2M7	- Data collection - Computing sediment loads - Data interpretation

NO.:	NAME:	TELEPHONE NO.:	TITLE:	MAILING ADDRESS:	INTERESTS:
12.	Dr. John Coakley	(416) 336-4881	Coastal Sedimentologist	National Water Research Inst. Canada Centre for Inland Waters Box 5050 867 Lakeshore Road Burlington, Ontario L7R 4A6	- Lake basin evolution and long-term trends in shore erosion on the Great Lakes - Sediment transport in the nearshore zone - Shore erosion processes in lakes and reservoirs
13.	Dr. Terry Day	(819) 953-1560	Head, Sediment Survey Section	Water Resources Branch Environment Canada Ottawa, Ontario K1A 0E7	- All aspects regarding sediment and management of the data collection program
14.	Art Derkson	945-7791	Fisheries Biologist	Fisheries Branch Manitoba Department of Natural Resources Box 40, 1495, St. James St. Winnipeg, Manitoba R3H 0W9	- Sediment effects on fish productivity in terms of physical (suffocation of fish eggs), chemical (water quality and nutrient transport) and ecological (effects on primary and secondary productivity)
15.	Marc Gaboury	945-7794	Fisheries Biologist	Fisheries Branch Manitoba Department of Natural Resources Box 40, 1495 St. James St. Winnipeg, Manitoba R3H 0W9	- Sediment as it relates to fish habitat, particularly in terms of how it affects spawning
16.	David Green	945-7817	Fisheries Technician	Fisheries Branch Manitoba Department of Natural Resources Box 40, 1495 St. James St. Winnipeg, Manitoba R3H 0W9	- Sediment effects on fish productivity
17.	Dennis Gregor	(306) 780-5321	Head, Surveys and Interpretation	Water Quality Branch Environment Canada 1901 Victoria Avenue Regina, Saskatchewan S4P 3R4	- Sediment as a transport phenomenon of nutrients, metals and toxic organic compounds in fluvial systems - Sinks and sources of these substances in the bottom sediments

NO.:	NAME:	TELEPHONE NO.:	TITLE:	MAILING ADDRESS:	INTERESTS:
18.	Ian Hagenson	945-7799	Fisheries Technician	Fisheries Branch Manitoba Department of Natural Resources Box 40, 1495 St. James St. Winnipeg, Manitoba R3H 0W9	- Sediment effects on fish productivity
19.	Bob Hale	949-7174	Chief, Water Resources Branch	Environment Canada 521 Federal Building 269 Main Street Winnipeg, Manitoba R3C 1B2	- Evaluation and implementation of changes to the sediment program in Manitoba
20.	Bob Halliday	(306) 780-5319	Regional Director Inland Waters Directorate	Environment Canada 1901 Victoria Avenue Regina, Saskatchewan S4P 3R4	- Management and integration of programs
21.	George Hanson	949-2434	Sediment Survey Engineer	Water Resources Branch Environment Canada 521 Federal Building 269 Main Street Winnipeg, Manitoba R3C 1B2	- All facets concerning the collection and interpretation of sediment data
22.	Dr. Bob Hecky	949-5217	Research Scientist	Freshwater Institute 501 University Cr. Winnipeg, Manitoba R3T 2N6	- Sediment as it impacts on primary production in lakes
23.	Ross Herrington	(306) 780-5337	Regional Engineer	Water Resources Branch #210, 1102 - 8th Avenue Regina, Saskatchewan S4R 1C9	- Operating a sediment collection program - Interpreting sediment data

NO.:	NAME:	TELEPHONE NO.:	TITLE:	MAILING ADDRESS:	INTERESTS:
24.	Wayne Hildebrand	476-5019	District Manager	Whitemud Watershed Conservation District Box 130 Neepawa, Manitoba R0J 1H0	- Prevention of erosion on agricultural land from wind and water - Sedimentation in drainage channels - Sedimentation impact on wildlife and fisheries
25.	Dave Hollinger	(807) 475-1215	Biologist	Ontario Ministry of the Environment 435 James Street South Thunderbay, Ontario P7C 5G6	- Contaminant cycling - Dredging spoil disposal evaluations - Sediment quality evaluations around industrial point sources
26.	Ed Houck	767-2101	District Manager	Alsona Watershed Conservation District Alsona, Manitoba R0H 0A0	- Sediment plugging of agricultural drains - Erosion from unstable areas - Sediment from wind erosion - Sediment implications for fisheries
27.	Roy Houston	453-2301	Municipal Project Manager	M.M. Dillon Ltd. 6 Donald Street South Winnipeg, Manitoba R3L 0K6	- Sediment as it relates to water quality - Designing potable water systems for communities
28.	Lance Howard	475-8686	Water Resources Engineer	Shawinigan Consultant Inc. #640 - 5 Donald Street Winnipeg, Manitoba R3L 2T4	- Sediment data in studies relating to the development of water resources projects - Potential and historic effects of development on the sediment within rivers, lakes and reservoirs - Evaluation of suspended and bed load data as related to hydro-electric projects
29.	Dr. Tog Jackson	(306) 975-5766	Research Scientist	National Hydrology Research Institute 11 Innovation Boulevard Saskatoon, Saskatchewan S7N 3H5	- Biogeochemical problems involving bottom sediments and suspended sediments in lakes rivers and reservoirs - Sources, pathways and fates of toxics associated with sediments

NO.:	NAME:	TELEPHONE NO.:	TITLE:	MAILING ADDRESS:	INTERESTS:
30.	Crawford Jenkins	945-2160	Chief, Soil and Water Management	Department of Agriculture Room 915, Norquay Building 401 York Avenue Winnipeg, Manitoba R3C 0P8	- Agricultural sources of sediment - Erosion problems - Impact of sediment on drainage networks - Sediment related to non-point pollution
31.	Bob Kury	949-5549	Water Supply and Pollution Control Engineer	DIAND 1100-275 Portage Avenue Winnipeg, Manitoba R3B 3A3	- Sediment as it affects municipal supply systems: reservoirs, water intakes and water treatment - Sediment as it affects land drainage systems
32.	Bernie Lussier	444-3652	District Manager	Cooks Creek Watershed Conservation District 639 Main Street Oakbank, Manitoba R0E 1J0	- Erosion from agricultural activities
33.	Val Macins	(807) 468-9841	Biologist	Ministry of Natural Resources Box 5080 Kenora, Ontario P9N 3X9	- Influence of sediment on fish habitat - Rates of sedimentation with various water flows - Sediment transport
34.	David MacMillan	943-6607	Senior Hydraulics and Structural Engineer	KGS Group Consultants 217A - 153 Lombard Avenue Winnipeg, Manitoba R3B 0T4	- Sediment transport - River scour and degradation - Reservoir sedimentation - River mechanics - Sediment station analysis
35.	Ruth Marr	477-6650	Environmental Scientist	MacLaren Plan Search Inc. 640-5 Donald Street Winnipeg, Manitoba R3L 2T4	- Sediment as it impacts on hydro-electric development in Northern Manitoba - Sediment component of work relating to impacts on water quality, reservoir productivity and fish - Remote sensing applications for collecting sediment data

NO.:	NAME:	TELEPHONE NO.:	TITLE:	MAILING ADDRESS:	INTERESTS:
36.	Greg McCullough	949-5203	Geomorphologist	Freshwater Institute 501 University Crescent Winnipeg, Manitoba R3T 2N6	- Shoreline erosion, transport and deposition in Precambrian Shield impoundments - Channel formation processes in diversions
37.	Dr. Rod McGinn	727-9771	Assistant Professor	Department of Geography Brandon University Brandon, Manitoba R7A 6A9	- Erosion, sedimentation and flooding problems along the eastern slopes of the Manitoba escarpment
38.	Allister McGregor	949-2241	Special Projects Engineer	PFRA 401 - 1 Wesley Avenue Winnipeg, Manitoba R3C 4C6	- Effects of sediment on the operation of small flood control dams - Reduction in storage in small reservoirs due to rare flood events - Methods of reducing sedimentation in reservoirs through watershed management techniques
39.	Mike McKernan	477-6650	Senior Scientist	MacLaren Plan Search Inc. #640 - 5 Donald Street Winnipeg, Manitoba R3L 2T4	- Sediment as it impacts on hydro-electric development in Northern Manitoba - Sediment component of work relating to impacts on water quality, reservoir productivity and fish - Monitoring sediment levels and interpreting the data to identify potential mitigative measures
40.	Ian McLaurin	949-5500	Regional Hydrologist	Water Resources Branch Environment Canada 521 Federal Building 269 Main Street Winnipeg, Manitoba R3C 1B2	- Data publications procedures, data interpretation and network analysis

NO.:	NAME:	TELEPHONE NO.:	TITLE:	MAILING ADDRESS:	INTERESTS:
41.	Lloyd Mohr	945-7816	Fisheries Technician	Fisheries Branch Manitoba Department of Natural Resources Box 40, 1495 St. James St. Winnipeg, Manitoba R3H OW9	- Sediment effects on fish productivity
42.	Tom Mosindy	(807) 468-9841	Fisheries Assessment Biologist	Lakes of the Wood Fisheries Assessment Unit Ministry of Natural Resources Box 5080 Kenora, Ontario P9N 3X9	- The effects of sediment on the quality of fish spawning habitat in rivers and lakes - The effects of sediment on water quality and how this relates to limiting production within fish populations
43.	Dr. Bob Newbury	835-2578	Resident Scientist	Wilson Creek Experimental Watershed P.O. Box 452 McCreary, Manitoba ROJ 1BO	- Stream rehabilitation
44.	Joe O'Connor	945-7794	Chief, Fisheries Enhancement	Fisheries Branch Manitoba Department of Natural Resources Box 40, 1495 St. James Street Winnipeg, Manitoba R3H OW9	- Sediment as it relates to fish productivity and fish habitat
45.	Dr. Frank Penkava	474-9819	Professor	Department of Agricultural Engineering University of Manitoba Winnipeg, Manitoba R3T 2N2	- Sediment as it relates to the design of irrigation and drainage systems
46.	Frank Penner	945-7404	Head, Special Services Section	Manitoba Water Resources Branch 1577 Dublin Avenue Winnipeg, Manitoba R3E 3J5	- Sediment as it affects: the operation of water resources projects, environmental approval of such projects, and the design and analysis of works to mitigate effects of sediment

NO.:	NAME:	TELEPHONE NO.:	TITLE:	MAILING ADDRESS:	INTERESTS:
47.	Bill Poole	747-2530	District Manager	Turtle Mountain Conservation District Box 508 Deloraine, Manitoba ROM 0M0	- Agricultural sources and the effects of sediment on depositional areas, storage capacity, water quality and wildlife
48.	Dr. Bill Rannie	786-9297	Professor	Department of Geography University of Winnipeg Winnipeg, Manitoba R3B 2E9	- Channel Morphology
48.	Manfred Samp	949-3123	Program Coordinator	PFRA 401 - 1 Wesley Avenue Winnipeg, Manitoba R3C 4C6	- Soil Erosion - Impacts of sediment on hydraulic facilities
50.	Barry Smith	(519) 821-0110	Sediment Survey Officer	Water Resources Branch Environment Canada 75 Farquahar Street Guelph, Ontario N1H 3N4	- Environmental Geology - Collection, analysis and interpretation of data from small watersheds
51.	Bert Smith	943-6607	Chief, Geotechnical/ Hydro Engineer	KGS Group Consultants 217A - 153 Lombard Avenue Winnipeg, Manitoba R3B 0T4	- Erosion of riverbeds banks and lake shore lines - Scouring/erosion of engineered embankments and shoreline protection - Water quality concerns - Erosion of agricultural lands
52.	Gordon Spafford	683-6363	President	Unies Ltd. 1666 Dublin Avenue Winnipeg, Manitoba R3H 0H1	- Application to water resources engineering such as: definition of natural physical processes involving lakes and rivers; hydrological investigations involving impact of land use changes; and, streamflow regulations, augmentation or diversion

NO.:	NAME:	TELEPHONE NO.:	TITLE:	MAILING ADDRESS:	INTERESTS:
53.	Milt Spitzer	(430) 292-5317	Regional Engineer	Water Resources Branch Environment Canada Room 854 - 220 4th Ave. S.E. Calgary, Alberta T2P 2M7	- Managing sediment data collection programs - Sediment data interpretation
54.	Suzanne Thérien-Richards	949-4813	Toxic Substances Officer	Environmental Conservation and Protection Service 800 - 275 Portage Avenue Winnipeg, Manitoba R3B 2B3	- Interaction of sediment with pesticides
55.	Jim Way	949-2434	Regional Engineer	Water Resources Branch Environment Canada 531 Federal Building 269 Main Street Winnipeg, Manitoba R3C 1B2	- Managing sediment data collection programs
56.	Larry Wiens	(306) 780-5329	Water Resources Engineer	Water Planning and Management Branch Environment Canada 1901 Victoria Avenue Regina, Saskatchewan S4P 3R4	- Erosion, sedimentation and transport in general
57.	Dwight Williamson	945-7030	Environmental Officer	Environment and Workplace Safety and Health Box 7, Building 2 139 Tuxedo Avenue Winnipeg, Manitoba R3N 0H6	- Sediment as it relates to impairment of water use for domestic consumption, aquatic life, wildlife and recreation - Suspended sediment as a transporter - of contaminants - Bottom sediment as a sink for contaminants
58.	Ted Yuzyk	(819) 953-1561	Fluvial Geomorphologist	Sediment Survey Section Environment Canada Ottawa, Ontario K1A 0E7	- Morphological studies - Sediment program evaluation - Sediment data interpretation - Sediment quality